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BIOSORPTION OF HEAVY METALS BY DEAD FUNGAL BIOMASS

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ABSTRACT

In recent times, due to unchecked industrial effluent treatment natural resources like land, air, water and soil are getting polluted. The major cause of this pollution is discharge of pollutants from untreated industrial effluent in to land and water that are containing toxic elements including various heavy metals viz. Cu, Ni, Zn, Mn, Fe, Cr etc. These metals are present as contaminants in the effluents which are released from different industries such as electroplating, mining, pulp industry etc. Biosorption is the most suitable bioremediation process to eliminate these heavy metals. Biosorption of heavy metal is carried out by using living cell and dead cells. This review discusses the advantages of dead biomass over living biomass in the process of biosorption.

KEYWORDS: Industrial Effluent, Heavy Metals, Bioremediation, Biosorption, Dead Fungal Biomass

INTRODUCTION

Most of the industries discharge heavy metals in their effluents without the proper treatment of waste water. This creates a major environmental pollution which is harmful to marine ecosystem as well as human health. Contamination of agricultural soil with heavy metals alters the soil pH and makes it poorly fertile. As these metals are present in the soluble form, it is toxic to the biological system due to bio accumulation leading to carcinogenic and mutagenic changes. Table 1 shows how these heavy metals present in the water are toxic to the biological and the ecological system. The response of micro-organisms towards toxic heavy metals is important by virtue of interest in the reclamation of the polluted sites (Hemambikaet al; 2011;Mehmooda et al; 2014).For removal of these toxic heavy metals various conventional processes carried out are depicted in figure 1. These technologies have several dis-advantages. (Ahalya et al; 2003)

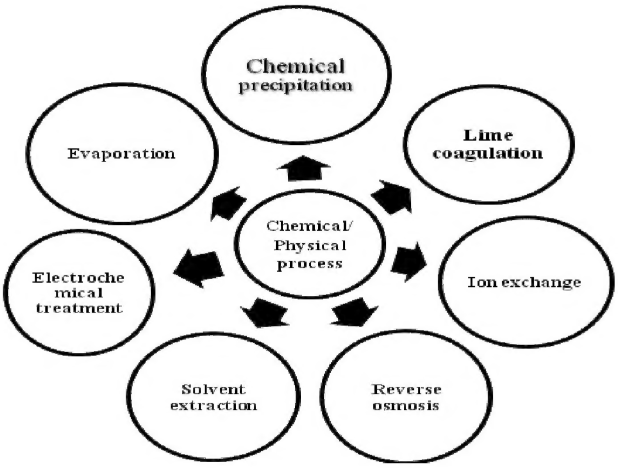

Figure 1: Different Chemical/Physical Process for Biosorption

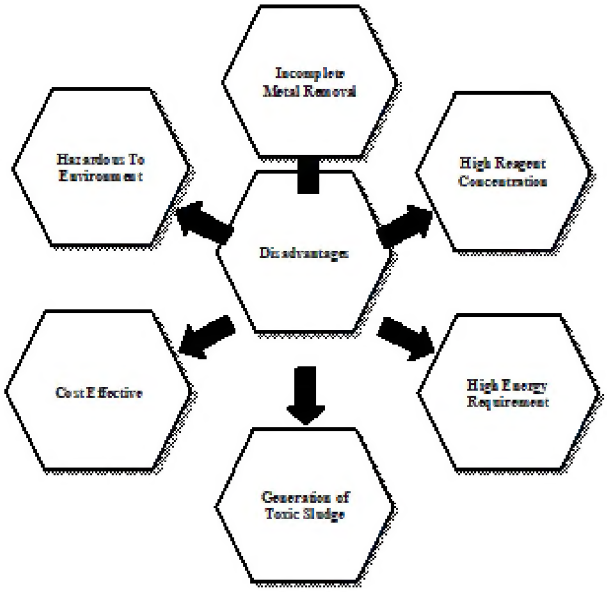

Figure 2: Disadvantages of Chemical Process

Table 1: Heavy Metals and Their Toxicity to Human Health

Industry	Heavy Metal	Effluent Quantity	Type of Water	Toxicity	References
Textile, tanning, wood preserving, petroleum refining, chrome plating	Cr Cr(VI)	0.027-0.122mg/l 0.1mg/l	Ground water Inland water	An Irritant causing nausea and vomiting, kidney and liver damage, damage to circulatory and nerve tissue, causes cancer in digestive tract and lungs	(Shankar et al; 2006; Navneet 2003; Ann et al;2012; Onwuka et al; 2011 AmnaJavaid et al; 2010)
Electroplating, welding, batteries, nuclear fission plant.	Cd Cd(II) Cd	0.051-0.184mg/l 0.003mg/l 0.48-1.62mg/l	Ground water Drinking water Wastewater	Kidney damage, bronchitis, gastrointestinal disorder, bone marrow cancer.	(Lamrood Prasad Y &RalegankarSachin D 2013; Samita et al 2012; Ann et al; 2012; Manisha et al; 2011)
Electroplating, iron and steel units, galvanized units.	Fe	–	–	Fatigue weakness, drowsiness, loss of appetite, constipation head ache, spots in vision, cold extremities.	(Navneet 2003; Ghosh et al; 2006)
Petrol based materials, automobile emission	Pb(II)	0.01mg/l	Drinking water	Liver, kidney, gastrointestinal, damage, mental retardation in children, damage to nervous system, circulatory system, blood forming system, reproductive system.	(Shankar et al; 2006; Navneet 2003; Samita et al 2012; Mehmoodaet al; 2014).

Table 1: Contd.,

Electroplating, ointment, refineries, metal plating, brass manufacturing	Zn	_	_	Zn fumes have corrosive effect on skin, causes damage to the nervous system, nausea and vomiting.	(Navneet 2003; Samita et al 2012; AmnaJavaid et al; 2010).
Paint and powder, batteries processing links	Ni Ni(II) Ni(II)	0.10-0.321mg/l 0.007mg/l 3.0mg/l	Groundwater Drinking water Inland water	Cause decreased body weight, heart and liver damage and skin irritation, dermatitis, highly soluble and carcinogenic to human health, gastrointestinal distress.	(Shankar et al; 2006; Lamrood et al; 2013; Navneet 2003; Ann et al 2012; AmnaJavaid et al; 2010).
Electroplating	Cu	0.21-1.35mg/l	Wastewater	Causing Anaemia, intravascular haemolysis, acute liver failure and renal failure with tubular damage and death and mild conditions nausea and vomiting, diarrhoea.	(AmnaJavaid et al; 2010; Manisha et al; 2011)
Electroplating	Co(II)	0.08-0.91mg/l	Wastewater	Overexposure causes vomiting, nausea and vomiting.	(Onwuka et al; 2011; Manisha et al; 2011)
Welding, fuel addition, ferromanganese production.	Mn	_	_	Inhalation or contact causes damage to the central nervous system.	(Samita et al 2012)
Metal smelters	As	0.41-0.31mg/l	Wastewater	Bronchitis, dermatitis, kidney, lung bladder, and skin cancer, neurological disorders, muscular weakness.	(Samita et al; 2012; Dinesh et al; 2007).
Paper, batteries.	Hg	0.59-1.75mg/l	Wastewater	Damage to the nervous system, protoplasm poisoning.	(Samita et al; 2012; Rahman et al; 2011; Ghosh et al; 2006; Manisha et al; 2011).

BIOREMEDIATION

Bioremediation is defined as the process to degrade the environmental contaminants into less toxic forms by means of various biological agents, used in table 2.(Kumar et al; 2011)**.** Figure 3 gives the examples of **bioremediation:**

(Li Y& Li B 2011). Table 3gives the list of Microorganisms that are resistant to heavy metals and which are studied for bioremediation.

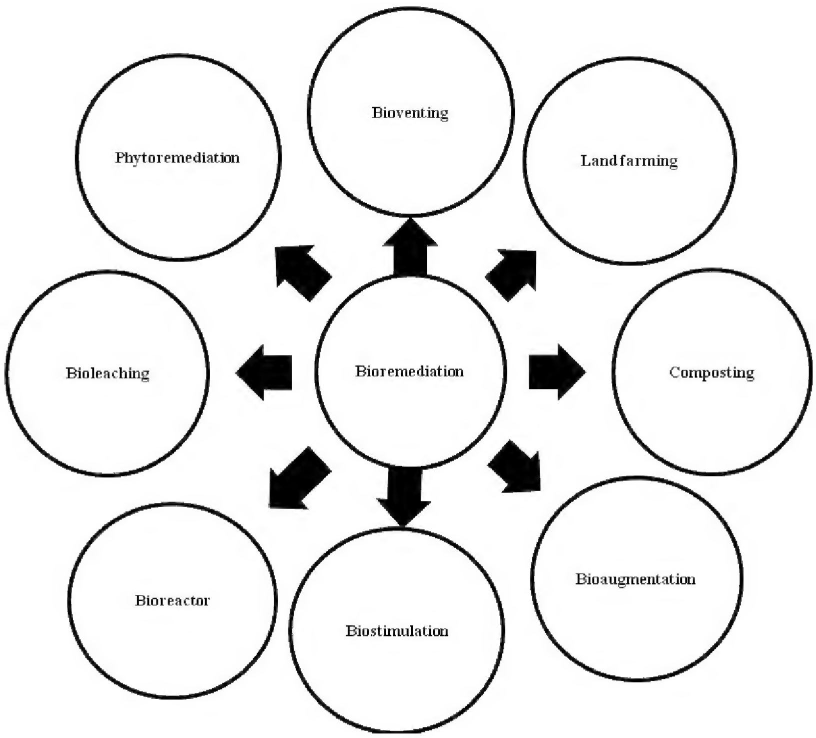

Figure 3: Bioremediation Process

Table 2: Different Types of Naturally Available Material Used for Biosorption Process (Samita et al; 2012)

Category	Examples
Bacteria	Gram Positive bacteria like (*Bacillus* sp., *Corenybacterium* sp., etc.), Gram Negative bacteria like (*Escherichia*sp.,*Pseudomonas* sp., etc.),,*Cyanobacteria* like (*Anabaena* sp., *Synechocystis* sp., etc)
Fungi	Molds like (*Aspergillus* sp., *Rhizopus* sp., etc.), Mushrooms like *(Agaricus* sp., *Trichaptum* sp., etc) Yeast like (*Saccharomyces* sp., *Candida* sp., etc.)
Algae	Micro-algae like (*Chlorella*sp.,*Chlamydomonas*sp., etc.) Macro-algae like (green seaweed (*Enteromorpha* sp., *Codium*sp.,etc.), brown seaweed (*Sargassum*sp.,*Eckloniasp*.sp.,etc) and red seaweed (*Geildium* sp., *Porphyra* sp., etc.)
Industrial wastes	Wastes from fermentation industry, food and beverage industry, activated, anaerobic sludges, etc.
Agricultural wastes	Wastes from fruit and vegetables like, Orange peels, wastes from fibrous plants, wheat bran, rice husk, soya bean hulls, etc.
Natural residues	Plant residues, sawdust, tree barks, seaweeds, etc.
Others	Chitosan and cellulose driven materials etc.

Table 3: Micro Organism Used for Bioremediation

Sr. No.	Organisms	Toxic Elements	References
1.	*Bacillus* species	Cu, Zn, Cd, Pb, Fe, Ni, Ag, Th, Ra and U	(Kim et al; 2007; Gupta et al; 2001; Doyle et al; 1980; Mehmooda 2014)
2.	*Pseudomonas aeroginosa*	Cd, Pb, Fe, Cu, U, Ra, Ni, Ag	(Jayashree et al; 2012; Pattus et al; 2000; Mehmooda et al; 2014).
3.	*Rhodotorularubra*	Hg	(Ghosh et al; 2006)
4.	*Saccharomyces cerevisiae*	Cu, Zn, Cd, Pb, Fe, Ni, Ag, Th, Ra, U, and Hg	(Ghosh et al; 2006; Machado et al; 2008; Mehmooda et al; 2014).
5.	Rhizopus	Cr	(Bai et al; 2001)

Table 3: Contd.,

6.	*Aspergillusniger*	Pb, Zn, Cd, Cr, Cu, Ni and chlorpyrifos	(Muraleedharanet al; 1990; Ahluwalia et al; 2006; Mukherjee et al; 1906;Mehmooda et al; 2014).
7.	*Cyanobacteria*	Pb, Hg and Cd	(Ghosh et al; 2006; Mehmooda et al; 2014).

The process of bioremediation by live organism it has limitations, which are as follows: (Kumar et al; 2011; Sonal Bhatnagar & ReetaKumari2013).

- Only some of the contaminants are biodegradable
- Bioaccumulation and bio magnifications
- Not all contaminants are treated; some heavy metals are not absorbed by organisms.
- Biological process is highly specific.
- Requires suitable environmental growth conditions.
- Appropriate level of nutrients and contaminants.
- Contaminants may be present in all the three phases (solid, liquid and gaseous) which might not be adequately bio remediated

To overcome these problems the process known as biosorption is applied, which is becoming an excellent bioengineering process heavy metal removal.

BIOSORPTION

Biosorption is considered to be an eco-friendly technique. This technique was first introduced by Ames Crosta Mills and Company Ltd in 1973. (Samita et al; 2012).Biosorption is defined as the ability of biological materials to accumulate heavy metals from waste water through physico-chemical. It can be also defined as the process that utilizes inexpensive dead biomass to sequester toxic heavy metals and useful for the removal of contaminants from industrial effluents. (Navneet 2003).The removal of heavy metal cations from aqueous effluents or their recovery can be done using dead cells. The biosorption process involving the use of dead biomass is more faster in comparison to living cells as it is cell surface based binding and displays high affinity for metal ion removal from aqueous solution(Qiaojunlian et al; 2010). According to investigations the possibility of living organism to accumulate metallic elements could be toxic (Samita et al; 2012). In comparison to living cells the use of dead biomass is an easy and a non-destructive method for recovery of adsorbed metal ions which allows regeneration and reuse of biosorbents. (QiaoJunlian et al; 2010) Table 4 discusses the biosorption capacity for different Microbes for different heavy metals.

Table 4: Biosorption Capacity of Different Microbe with Different Heavy Metals

Sr. No.	Heavy Metal	Organism	% of Sorption	References
1.	Cd	*Penicillium* *Aspergillustamarii* *Trichoderma* species	95.27% 51.69% 89%	(Hemambika et al; 2011; Sahin et al; 2013; Ann et al; 2012).
2.	Ni	*Aspergillustamarii* *Trichoderma* species	58.74% 77-89.41%	(Ann et al; 2012; Sahin et al; 2013).
3.	Cu	*Amanita muscaria* *Spirulinaplatensis*	~90% ~90.6%	(Tomko et al; 2006; Ali et al; 2014).

Table 4: Contd.,

4.	Zn	*Aspergillustamarii*	54.3%	(Sahin et al; 2013).
5.	Pb	Mycelial *Aspergillustamarii*	74% 98.14%	(Sahin et al; 2013; Mehmooda et al; 2014).
6.	Sb	*Agaricuscampester*	~95%	(Tomko et al; 2006).
7.	Al	*Agaricuscampester*	~95%	(Tomko et al; 2006).
8.	Cr	*Trichoderma* species	81.5%	(Ann et al; 2012; Mehmooda et al; 2014)
9.	Mn	*Aspergillustamarii*	46.99%	(Sahin et al; 2013).
10.	Fe	Mycelial	46%	(Sahin et al; 2013).

The mechanism of biosorption represented in Figure 4 which includes coplexation, precipitation, reduction, chelation and ion exchange

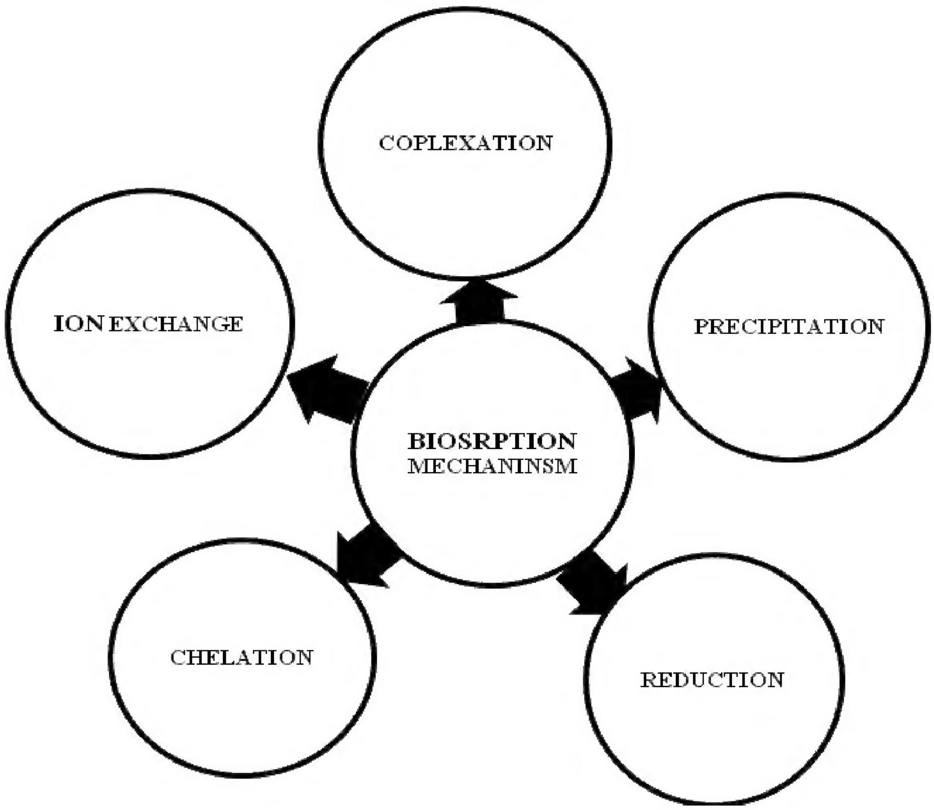

Figure 4: Schematic Representation of Biosorption Mechanism

Advantages of biosorption over other methods are listed below in Figure 5 (Ahalya et al; 2003: Hemabika et al; 2011; Iqbal et al; 2005; Samita et al; 2012).

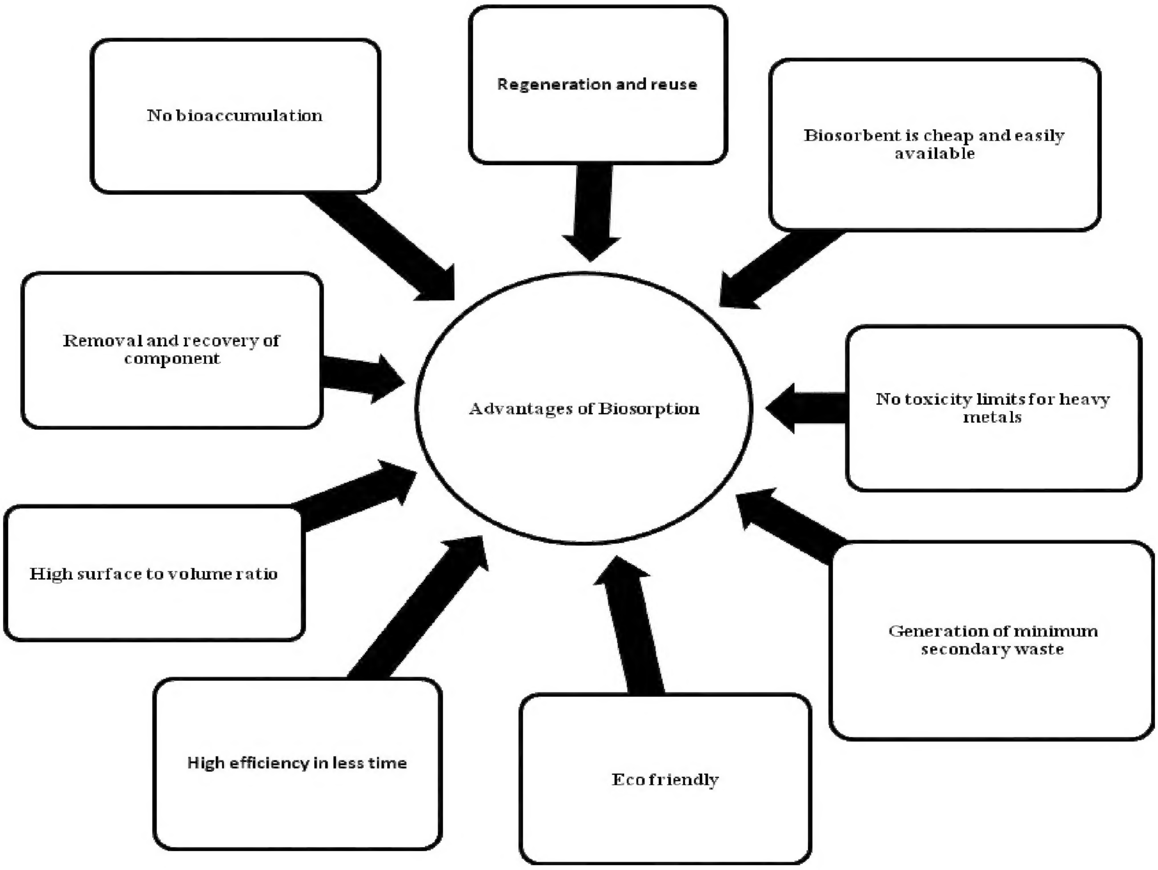

Figure 5: Schematic Representation of Advantages of Biosorption

CONCLUSIONS

Removal of heavy metals is a must as these metals are toxic to ecological and biological system. Biosorption using dead fungal biomass is considered to be an important process for the removal of heavy metal as it is proven to be more effective than the conventional methods for the removal of toxic heavy metals from surrounding. Dead biomass is used because of its tremendous power of absorption without giving any harmful secondary compound. Fungal dead biomass can be reused after the desorption process

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